Modeling a Full Adder in an Ising Spin Quantum Computer with 1000 Qubits using Quantum Maps

Dmitry I. Kamenev, Gennady P. Berman, and R. B. Kassman (T-13), and V. I. Tsifrinovich (Polytechnical University); ***dkamenev@lanl.gov***

In order to be useful, a quantum computer must contain many quantum bits (qubits) in its register. The operation of this many-qubit quantum computer is a complex quantum-mechanical process. First of all, a quantum computer must be isolated from its environment. However, even for a completely isolated quantum computer there are errors induced by electromagnetic pulses and interqubit interactions, so that reliable quantum protocols (sequences of pulses) must be developed and numerically tested.

We have developed a reliable protocol and numerically simulated a quantum full adder with 1000 operating qubits [1]. The total number of qubits in the qubit chain, including carry-over qubits, is 2001. The quantum adder is an essential capability of a quantum computer, just as classical adder is essential for a digital computer. The quantum register is represented by a spin chain with constant Ising interaction between the spins.

An original method based on quantum maps was used for our computations. This method allows one to reduce the time required for the quantum simulations by orders of magnitude and to make modeling and benchmarking of a multiqubit quantum computer possible. In Fig. 1 the quantum map approach is compared with an accurate numerical solution for the full adder for a relatively small number (11) of spins in the spin chain. A randomly chosen 5-bit number was added with a superposition of 4 randomly chosen quantum states in the register using quantum maps and exact numerical solution. The error caused by unwanted actions of the electromagnetic pulses on all qubits of the chain is plotted in the figure as a function of the number of applied pulses. In Fig. 2 the linear accumulation of the probability error is plotted as a function of the pulse number during addition of a randomly chosen 1000-bit number to a superposition of a 20 randomly chosen quantum numbers in the quantum register.

[1] D.I. Kamenev, G.P. Berman, R.B. Kassman, and V.I. Tsifrinovich, "Modeling Full Adder in Ising Spin Quantum Computer with 1000 Qubits using Quantum Maps," *International Journal of Quantum Information* **2**, 323 (2004).

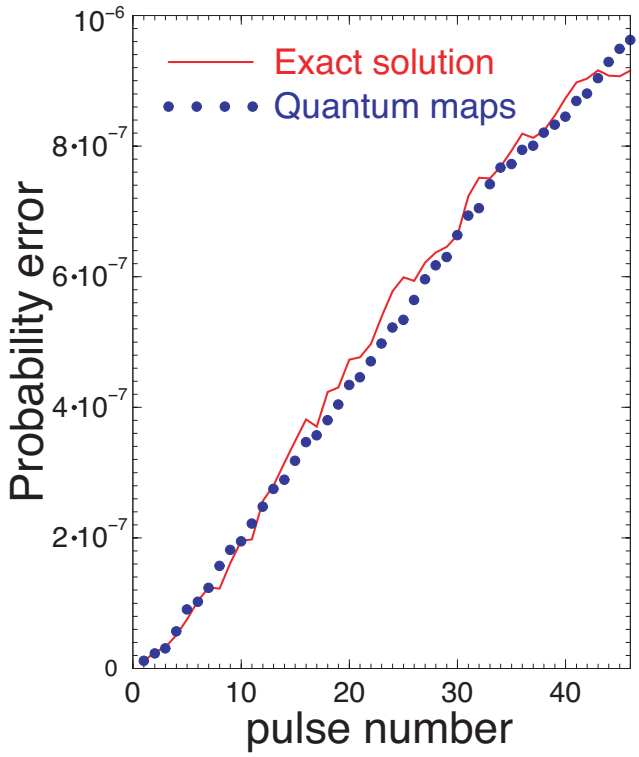

Figure 1—
The quantum map approach compared with an accurate numerical solution for the full adder for a relatively small number (11) of spins in the spin chain.

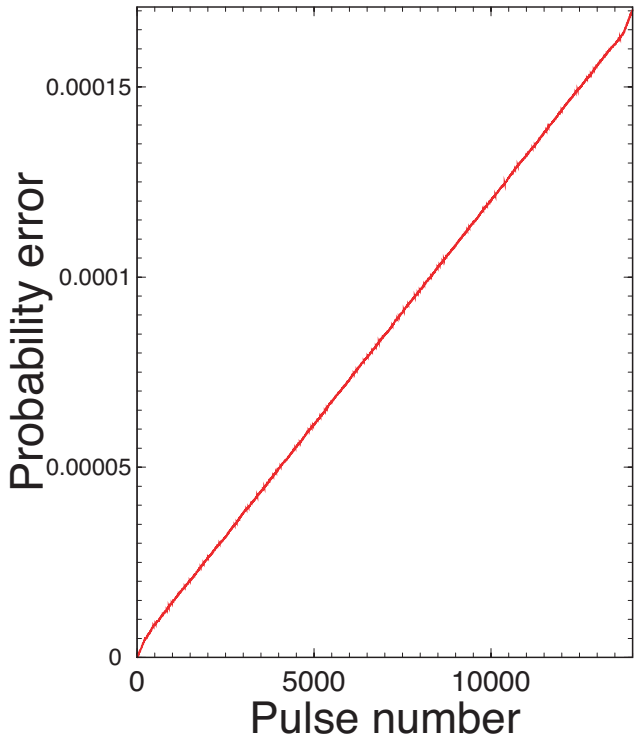

Figure 2—
The linear accumulation of the probability error is plotted as a function of the pulse number during addition of a randomly chosen 1000-bit number to a superposition of a 20 randomly chosen quantum numbers in the quantum register.